EXHIBIT F

Dean Gatzlaff; David Geltner
Real Estate Finance; Spring 1998; 15, 1; ProQuest Direct Complete
pg. 7

A Transaction-Based Index of Commercial Property and its Comparison to the NCREIF Index

Dean Gatzlaff

is associate professor of real estate at Florida State University's College of Business in Tallahassee, Florida.

David Geltner

is professor of real estate at the University of Cincinnati's College of Business Administration in Cincinnati, Ohio.

Background: Why We Need a Transaction-Based Price Index[1]

Value indexes that map the periodic movements of asset prices provide valuable information not only to economists studying the market, but to practitioners and investors participating in the market. Understanding historical price volatility, correlations and autocorrelations, and identifying the timing and magnitudes of "peaks" and "troughs" in the market, allows investors to develop better price expectations and to make more-informed investment decisions.

Unlike stock and bond market prices, measuring asset price movements in property markets is particularly difficult, because the assets are highly heterogeneous and infrequently traded. In addition, property markets are dominated by private and negotiated transactions of whole assets, rather than public auctions of homogeneous shares as in the stock and bond markets.

Today, the most commonly used index of investment performance of income property is the NCREIF Property Index (NPI), which is based on the appraised values of properties held for tax-exempt institutions by members of the National Council of Real Estate Investment Fiduciaries (NCREIF). While the NPI provides much useful information, it has some problems. Perhaps most notably, both practitioners and academicians have wondered about the extent to which the NPI presents a "smoothed" or "lagged" representation of asset price changes in the commercial property market that the index is often assumed to represent. Such smoothing and lagging may be due to the nature of the appraisal process or to the nature of the aggregation in the index construction and reporting methodology.[2]

Another issue of interest is the nature of the

possible differences in the investment returns performance to the so-called "institutional quality" properties held by NCREIF members compared to a broader sample of commercial properties. Institutional properties tend to be confined to the largest and highest quality commercial buildings in prime metropolitan locations. There is some evidence, for example, that the generally smaller commercial properties (in common with housing) may not have fared as badly as the institutional properties in the slump in property prices that occurred at the end of the 1980s and early 1990s.[3]

Both of these issues have obvious implications for the use of the NPI in portfolio analysis or as a benchmark of commercial property performance, and both of these issues are addressed in our study.[4] First, we explore a new type of data source and statistical methodology for estimating period-by-period capital return indexes for commercial property that is not dependent on appraisal valuations and that avoids temporal aggregation.[5] Specifically, we apply to a sample of historical commercial property transactions the time-weighted repeat-sale index construction methodology that has been pioneered in housing literature. Second, our data consist of the repeat sales occurring within the *entire population* of commercial properties within the metropolitan areas of the state of Florida. This population is dominated by the smaller, "non-institutional" properties. Thus, our index portrays the performance of this broader class of commercial properties during the market crash of the early 1990s, which can be compared with the NCREIF index of institutional property performance during the same period. In particular, our study compares the performance of our index with that of the relevant geographic and property type sub-indexes of the NPI.

A brief overview of the repeat-sales index estimation method is presented followed by a description of the data used to estimate the indexes. The characteristics of the transaction-based commercial property price movements are then compared with the NPI and also with the housing market. We end with a summary of our findings.

Methodology: How the Repeat-Sales Index Works

The repeat-sales regression (RSR) methodology was first proposed as a procedure for developing real estate price indexes thirty-five years ago by Bailey, Muth, and Nourse [1963]. Important advancements in the technique have been made in the past decade by Case-Shiller [1989], Clapp-Giacotto [1992], Gatzlaff-Haurin [1997], and Goetzmann [1992], and others. The RSR has been applied widely in both academic and industry studies of housing in the U.S. To date, however, no one has applied the RSR procedure to *commercial* property prices in this country.[6]

A different, but closely related, type of statistical procedure, the "hedonic regression" (HR), has been applied to commercial properties to estimate transaction-based price indexes in a few cases.[7] However, the hedonic procedure requires good data availability on a number of property characteristic variables, and from an econometric perspective the HR raises a number of specification issues and problems of omitted variables.[8] In practice, many of the HR indexes of commercial property developed so far appear rather "noisy."[9] A possible reason for the RSR procedure not yet being applied to commercial properties is that commercial properties are less numerous than houses (and transact less often) so data bases contain substantially fewer commercial property sales transactions than housing transactions. This is particularly critical for the RSR procedure, because it can only use a subset of all transactions, namely those where the same property transacts twice (or more) during the period covered by the data base. This usually greatly reduces the total number of observations on which the index can be estimated, especially when the property turnover rate is low, as is often the case with a commercial property. One of the methodological issues our study seeks to address is whether the RSR technique can be successfully applied to the commercial property market at a practical empirical level that can provide useful information for decision makers, in spite of the repeat-sales data restriction.

In this section of our article, a simple numerical example of the RSR is presented to clarify for readers how the basic procedure works to produce an index of the period-by-period capital returns (or percentage asset price changes) to the properties in a given population, using repeat-transaction price data from infrequently and irregularly traded individual properties.[10] In this example we posit a population consisting of four commercial properties whose "true

periodic capital returns" were 5% in 1995, 3% in 1996, and 7% in 1997. We will shortly explain more specifically what we mean when we say that these were the "true" capital returns in this population. For now, however, suppose that these underlying true returns are not directly observable, because not every property in the population transacts every year. In particular, let us suppose that the only transactions among this population were those reported in Exhibit 1. For example, Property #1 was sold at the end of 1994 for $1,000,000, and then sold again at the end of 1997 for $1,157,205.

Let us now clarify what we mean when we say that the "true" capital return in this population is 5%, 3% and 7% in the years 1995-1997. We mean that if we apply these periodic capital return rates to each property's first transaction price by growing that price at the given rate for each subsequent period, we will obtain the second transaction price for each property. This is seen as follows.

$$\begin{aligned}
&\text{Prop.\#1: } 1{,}000{,}000 \times 1.05 \times 1.03 \times 1.07 = 1{,}157{,}205\\
&\text{Prop.\#2: } 2{,}299{,}000 \times 1.05 = 2{,}413{,}950\\
&\text{Prop.\#3: } 695{,}466 \times 1.05 \times 1.03 = 752{,}146\\
&\text{Prop.\#4: } 1{,}738{,}425 \times 1.03 = 1{,}790{,}578 \qquad (1)
\end{aligned}$$

For example, the first property sold at the end of 1994 for $1,000,000. If that price grew by 5% during 1995, by another 3% during 1996, and by another 7% during 1997, then we would obtain the second transaction price of $1,157,205 at the end of 1997. Turning to the fourth property, we see that it had its first transaction later than the others, selling for $1,738,425 at the end of 1995, and its second transaction occurred at the end of the following year, so its second price reflects only the 3% growth rate which prevailed during 1996. As the historical periodic growth rates of 5%, 3%, and 7% apply individually to all four properties in our example population, it seems apparent that these rates indeed accurately reflect the periodic capital returns in this population.

In this example, we assume that we already knew the true historical periodic capital returns in the population. Let us now see how the RSR procedure could be used in this population to estimate these returns simply from the transaction price data, if we did not already know what the returns were. Let "r_t" stand for the unknown value of the return in year "t," so that our equations include only the observable transaction price data and these unknowns:

$$\begin{aligned}
&\text{Prop.\#1: } 1{,}000{,}000 \times (1 + r_{95}) \times (1 + r_{96}) \times (1 + r_{97}) = 1{,}157{,}205\\
&\text{Prop.\#2: } 2{,}299{,}000 \times (1 + r_{95}) = 2{,}413{,}950\\
&\text{Prop.\#3: } 695{,}466 \times (1 + r_{95}) \times (1 + r_{96}) = 752{,}146\\
&\text{Prop.\#4: } 1{,}738{,}425 \times (1 + r_{96}) = 1{,}790{,}578
\end{aligned}$$

Next, we divide both sides by the first transaction price, and switch the sides of the equals sign:

$$\begin{aligned}
&\text{Prop.\#1: } 1{,}157{,}205/1{,}000{,}000 = (1 + r_{95}) \times (1 + r_{96}) \times (1 + r_{97})\\
&\text{Prop.\#2: } 2{,}413{,}950/2{,}299{,}000 = (1 + r_{95})\\
&\text{Prop.\#3: } 752{,}146/695{,}466 = (1 + r_{95}) \times (1 + r_{96})\\
&\text{Prop.\#4: } 1{,}790{,}578/1{,}738{,}425 = (1 + r_{96})
\end{aligned}$$

To linearize this system we need to make it additive rather than multiplicative, so we take the natur-

Exhibit 1

Example Price Data for Four Properties 1994-1997

Property\Year	1994	1995	1996	1997
Property #1	$1,000,000	NA	NA	$1,157,205
Property #2	$2,299,000	$2,413,950	NA	NA
Property #3	$695,466	NA	$752,146	NA
Property #4	NA	$1,738,425	$1,790,578	NA

Note: All transactions occurred at the end of the calendar year.

al logarithm of both sides of each equation (and recall that the log of a product equals the sum of the logs):

Prop.#1: $LN(1,157,205/1,000,000) = LN(1+r_{95}) + LN(1+r_{96}) + LN(1+r_{97})$
Prop.#2: $LN(2,413,950/2,299,000) = LN(1+r_{95})$
Prop.#3: $LN(752,146/695,466) = LN(1+r_{95}) + LN(1+r_{96})$
Prop.#4: $LN(1,790,578/1,738,425) = LN(1+r_{96})$

Now recall that $LN(1+r_t)$ is the "continuously compounded" rate of return in period "t."[11] Note that the right-hand side (RHS) of the above equations can be equivalently expressed as the sum of a series of products defined as follows. Each product corresponds to one period of time. The product equals the continuously compounded return for that period multiplied by a dummy variable which equals one for time periods between the two transactions and zero otherwise:

Prop.#1: $LN(1,157,205 / 1,000,000) = LN(1+r_{95}) \times 1 + LN(1+r_{96}) \times 1 + LN(1+r_{97}) \times 1$
Prop.#2: $LN(2,413,950/2,299,000) = LN(1+r_{95}) \times 1 + LN(1+r_{96}) \times 0 + LN(1+r_{97}) \times 0$
Prop.#3: $LN(752,146/695,466) = LN(1+r_{95}) \times 1 + LN(1+r_{96}) \times 1 + LN(1+r_{97}) \times 0$
Prop.#4: $LN(1,790,578/1,738,425) = LN(1+r_{95}) \times 0 + LN(1+r_{96}) \times 1 + LN(1+r_{97}) \times 0$

It should now be obvious how we can use linear regression procedures to estimate the unknown periodic returns.[12] The observations on which the regression will be estimated consist of the repeat-sales transaction price pairs (the rows corresponding to the four properties above). The left-hand side (LHS), or dependent variable, in the regression is the log price relative for each observation: $LN(P_{is}/P_{if})$, where P_{it} is the transaction price observed for property (observation) "i" in time period "t," and t = f corresponds to the time period of the first sale while t = s corresponds to the time period of the second sale. The RHS variables of the regression consist purely of dummy variables corresponding to each time period, defined as above (1 if the time period is between the two transactions, 0 otherwise).[13] In this form, it is easy to see that the RHS regression parameters to be estimated, labeled "β_t," correspond to the continuously compounded returns each period: $\beta_t \equiv LN(1+r_t)$.

For our three-year example, the regression equation would be expressed as follows:

$$Y = D\beta + \varepsilon$$

where: Y is a column vector of the log price relative observations, $Y_i \equiv LN(P_{is}/P_{if})$ for i = 1, ..., n (where n is the number of repeat-sales pairs); β is a column vector of period-by-period capital returns; D is a dummy variable matrix whose rows correspond to the observations and columns correspond to the time periods; and ε is a column vector of the regression "error" term.

The regression error results from "noise" in the property transaction prices. To understand what is meant by "noise," consider that the LHS variable is the log price relative of each observation. In other words, the LHS is the cumulative capital return for each observation across the calendar time between the two transactions. The regression error for each observation is the difference between what the regression *predicts* the cumulative return would be for that observation, versus what the cumulative return is actually observed to be for that observation.

For our three-period, four-observation numerical example the RSR regression would be estimated by the following system of four linear equations, where the β_t are the estimated parameter values (continuously compounded periodic capital returns), and the u_i are the residuals:

$$LN(1,157,205/1,000,000) = 0.1460 = \hat{\beta}_{95} \times 1 + \hat{\beta}_{96} \times 1 + \hat{\beta}_{97} \times 1 + u_1$$
$$LN(2,413,950/2,299,000) = 0.0488 = \hat{\beta}_{95} \times 1 + \hat{\beta}_{96} \times 0 + \hat{\beta}_{97} \times 0 + u_2$$
$$LN(752,146/695,466) = 0.0783 = \hat{\beta}_{95} \times 1 + \hat{\beta}_{96} \times 1 + \hat{\beta}_{97} \times 0 + u_3$$
$$LN(1,790,578/1,738,425) = 0.0296 = \hat{\beta}_{95} \times 0 + \hat{\beta}_{96} \times 1 + \hat{\beta}_{97} \times 0 + u_4 \quad (2)$$

The regression estimation must solve this system simultaneously. Note that if we ignore the residual terms there are three unknowns in this system, namely the three periodic-return parameters to be estimat-

ed. As there are more than three equations, there may not exist a single solution that solves all four equations (if the equations are not consistent). However, we can always find a solution for the parameter values that minimizes the sum of the squared residuals, that is, which minimizes the sum: $u_1^2 + u_2^2 + u_3^2 + u_4^2$. Such a solution would correspond to "ordinary least squares" (OLS) estimation of the regression. In this numerical example, it is easy to see what the solution is, because in fact the four equations are consistent. The following solution will cause the sum of squared errors to equal exactly zero, which is certainly the minimum possible sum of squares:[14]

$$\hat{\beta}_{95} = 0.0488 = \mathrm{LN}(1.05)$$

$$\hat{\beta}_{96} = 0.0295 = \mathrm{LN}(1.03)$$

$$\hat{\beta}_{97} = 0.0677 = \mathrm{LN}(1.07)$$

Furthermore, converting these estimated continuously compounded returns to annual wealth relatives with simple returns (by taking: $\mathrm{EXP}(\hat{\beta}_t) \equiv (1+r_t)$), we can compare equation system (2) with equation system (1) and note that these two systems are identical with the above solution for equation (2) and all the residuals set equal to zero: $u_1 = u_2 = u_3 = u_4 = 0$. This reflects the fact that, in the previous solution to equation system (2), that is, in our OLS estimation of the RSR for our numerical example, we have recovered the exact true periodic capital returns for our four-property population. (Recall that the true returns for 1995, 1996, and 1997 are 5%, 3%, and 7%.) Thus, we see how the RSR procedure yields an estimate of the periodic capital returns in a population of properties for which we can only infrequently and irregularly observe transaction prices within the individual properties. All we require is that at least one transaction price must be observable in the population during each period for which we want to estimate a population return, and the total number of repeat-sale pair observations must at least equal the number of time periods for which we wish to estimate periodic returns.

The reason why the RSR obtained *exact* true returns in this example is that there was *no noise* in this case. That is, all the observed transaction prices of every property were exactly consistent with the true underlying population returns. This is why the four equations in the estimation system were consistent and the regression residuals were all zero. Of course, this will not generally be the case in the real world. However, in the real world there typically will be many more degrees of freedom in the regression estimation than were present in this example. (Here there was only one more observation than the number of periods of time for which we wished to estimate returns.) The more transaction observations per time period, the better the regression estimation can filter out the transaction noise. As noise is apparent in an estimated index by the presence of excess volatility and negative autocorrelation in the returns time series (a "spiky" or "sawtooth" appearance in the returns or the index levels), it should be possible in practice to judge whether the index has successfully filtered out most of the noise. This question is one of the focuses of this article.

In practice, it should be noted that the nature of transaction noise will cause a type of statistical problem known as "heteroskedasticity" in RSR index estimation.[15] For this reason, a three-stage "weighted least squares" (WLS) procedure is usually used in the housing literature to estimate RSR indexes, and this procedure will be applied in the present study as well.[16]

Data: Florida DOR Transaction Prices

The transaction data used for this study were obtained from the Florida Department of Revenue's (DOR) 1997 property tax records. These data are compiled each year by the DOR under a statutory provision requiring the auditing of each county's property assessments. The complete set of records includes information on every parcel in the state of Florida. Data were available to the authors that included transactions recorded through July 1997.

Property records were obtained for the twenty Metropolitan Statistical Areas (MSAs) located in the state of Florida. The MSAs represent all of the major urban areas in Florida, approximately 85% of the state's population, and over 6.7 million properties (residential and commercial). The information indicated for each parcel includes the lands-use code, the assessed property and land values, the most recent sale price and closing date (year and month), the second most recent sales price and closing date (year and month), and approximately forty other property- and owner-specific variables.[17] Commercial properties that sold twice between 1975 and 1997 were used to estimate annual RSR indexes for the aggregate mar-

Exhibit 2

Descriptive Statistics of the Transaction Data Listed by Year of Sale, 1975 - 1997

Year	No. Obs.	Median Sale Price ($000)	Mean Sale Price ($000)	Std. Dev. Sale Price ($000)	Min. Sale Price ($000)	Max. Sale Price ($000)
1975	81	350	754	1,209	150	8,910
1976	113	300	516	537	150	3,210
1977	137	315	568	838	150	8,040
1978	147	300	715	1,093	150	8,493
1979	182	323	715	1,011	150	8,053
1980	226	421	1,233	2,026	150	9,250
1981	287	350	863	1,553	150	15,000
1982	268	415	1,090	2,964	150	42,200
1983	353	420	1,193	2,427	150	20,000
1984	414	398	1,194	2,115	150	20,735
1985	482	410	1,177	2,217	150	22,173
1986	573	425	1,278	3,174	150	35,400
1987	425	375	1,101	2,690	150	35,480
1988	506	447	1,333	2,595	150	20,734
1989	569	475	1,314	2,420	150	26,500
1990	471	450	1,096	1,774	150	16,800
1991	448	449	1,516	2,887	150	18,796
1992	470	448	1,371	3,089	150	32,550
1993	551	435	1,267	2,625	150	23,666
1994	496	460	1,224	2,701	150	24,200
1995	533	495	1,385	3,812	150	67,000
1996	765	572	1,843	4,058	150	35,200
1997	249	595	1,738	3,359	150	32,900

Note: The above statistics are calculated using sale price information from both the first and second sales of the 4,373 repeat-sale pairs. The statistics reported for 1997 are based on observations that extend through, and include, 1997:6 (July)

ket as well as five market sectors. However, their comparison with the NCREIF indexes is limited to later periods when sufficient NCREIF properties were available for the NPI to be produced for Florida or the Southeast Region.

Properties were selected from the DOR data set that represented five sectors of the real estate market: 1) apartment, 2) retail, 3) office, 4) hotel, and 5) industrial.[18] A total of 124,871 properties were identified as having the appropriate land-use code for one of the five sectors (apartment, 11,280; retail, 36,232; office, 37,625; hotel, 4,548; and industrial, 35,186). Properties were then identified that reported both a most recent and second most recent sale price (and sale date) during the 1975 (January) to 1997 (July) period that had values greater than $150,000.[19]

Three steps were conducted to mitigate the effect that properties that experienced substantial capital improvements (renovations or demolition) during the study period would have on the RSR index estimates. First, properties were excluded that were identified as being a vacant parcel on either its first or

second sale date. Second, those properties that indicated an effective-year-built after either its first or second sale date were deleted.[20] Finally, the repeat-sale data were limited to those properties with holding periods of at least three years between their transaction dates.[21] We believe that the resulting repeat-sales sample largely reflects the effects of no more than routine capital improvement expenditures on the properties between transaction dates.[22] The final data set includes 4,373 properties (apartment, 1,114; retail, 822; office, 979; hotel, 482; and industrial, 946) that were recorded as selling at least twice during the index construction period.

Descriptive summary statistics are reported for the repeat-sale data in Exhibit 2. This exhibit indicates that the data represent a wide range of property values ($150,000 to $67,000,000). In addition, the median sale prices of the properties that sold each year ranged from a low of $300,000 in 1976 (and 1978) to a high of $595,000 in 1997. The skewed nature of the sale price data is evidenced by the large differences in the yearly median and mean prices (and the large standard deviations).

Exhibit 3 reports the median, mean, standard deviations, minimum, and maximum sale price information by property type for the 1996 and 1997 periods. It is interesting to note that the apartment and hotel sectors were generally higher priced than the retail, office, and industrial sectors. However, the maximum sale prices in all sectors are reported to be similar, with the exception of the retail sector which was less than the others by a factor of two to three.[23] A comparison of these data, and data from previous periods, with those properties reporting only a single sale date indicates that the characteristics reported in Exhibits 2 and 3 are generally representative of the entire time series and population.

It is important to note that the vast majority of properties included in our repeat-sales data base are much smaller than the typical property included in the NCREIF index.[24] For example, the mean value of Florida properties in the NCREIF index during the second quarter of 1997 was $23,158,000, which is some thirteen times the mean 1997 sale price in our repeat-sales sample, and almost forty times our median sale price in that year.

Results: "Look Mike, No Smoothing!" (or Is There?)

Exhibit 4 shows the results of our RSR price index estimation for Florida commercial properties based on the aggregate sample of all 4,373 repeat-sales pair observations, including all property types. The estimated annual periodic capital returns, and the resulting index level (set arbitrarily to a value of 1.00 as of the end of 1975) are reported in Exhibit 4A, along with some basic summary statistics on the return time series.[25] Exhibit 4B charts the price level index across the 1975-1997 period.

Exhibit 3

Descriptive Statistics of the Transaction Data
Listed By Sector for 1996 -1997

Sector	No. Obs.	Median Sale Price ($000)	Mean Sale Price ($000)	Std. Dev. Sale Price ($000)	Min. Sale Price ($000)	Max. Sale Price ($000)
Apartment	284	825	2,169	3,780	150	32,900
Retail	219	407	1,103	1,880	150	12,240
Office	235	365	1,371	3,271	150	34,000
Hotel	101	950	2,337	4,103	158	35,200
Industrial	175	450	2,442	5,916	153	27,580

Note. The statistics reported above are based on sales that occurred in 1996 through July of 1997

Exhibit 4A

The RSR Index of All Florida Commercial Property

Annual Return Summary Statistics

GMEAN	4.23%
MEAN	4.44%
MEDIAN	3.56%
STDEV	6.99%

Return History

Year	End of Year Index Level	Capital Return
1975	1.00	
1976	1.18	18.11%
1977	1.16	-1.46%
1978	1.25	7.46%
1979	1.50	19.90%
1980	1.77	18.34%
1981	1.79	0.73%
1982	1.84	3.07%
1983	1.96	6.46%
1984	1.97	0.55%
1985	2.05	4.04%
1986	2.04	-0.71%
1987	2.17	6.65%
1988	2.09	-3.72%
1989	2.13	1.68%
1990	2.10	-1.07%
1991	2.03	-3.63%
1992	1.93	-4.62%
1993	2.03	5.17%
1994	2.19	7.58%
1995	2.18	-0.21%
1996	2.30	5.47%
1997	2.49	7.98%

The first conclusion suggested by these results is that the time-weighted RSR technique we employed here appears to be feasible for commercial property price index construction from a practical and statistical perspective, in this case with an average of about 200 repeat-sales observations per period. While there is some evidence of noise in this index during the first few years (possibly during 1976-1980), in general the all-property index appears free of serious noise problems. The overall annual volatility of 6.99% per year does not appear excessive, as it is considerably below the volatility typically observed in the stock market, for example. The overall first-order autocorrelation coefficient is +21%, which suggests a mildly sluggish asset market, but does not evidence a noise problem (which would be manifested by negative autocorrelation).[26]

In an extension of the work reported in this article, the authors have carried this question a bit farther, developing RSR price indexes without apparent excessive noise for the individual property type sectors within Florida, even though these indexes were estimated sometimes with as little as an average of only about twenty repeat-observations per period. This was done using a Bayesian/Method of Moments estimation technique developed by Goetzmann [1992], using the a priori assumption that the autocorrelation behavior in the capital returns of the individual property sectors would be similar to that observed in the overall commercial property index described here. (A description of the sectoral indexes is available in the RERI Working Paper by the authors, entitled: "A Repeat-Sales Transaction-Based Index of Commercial Property.")

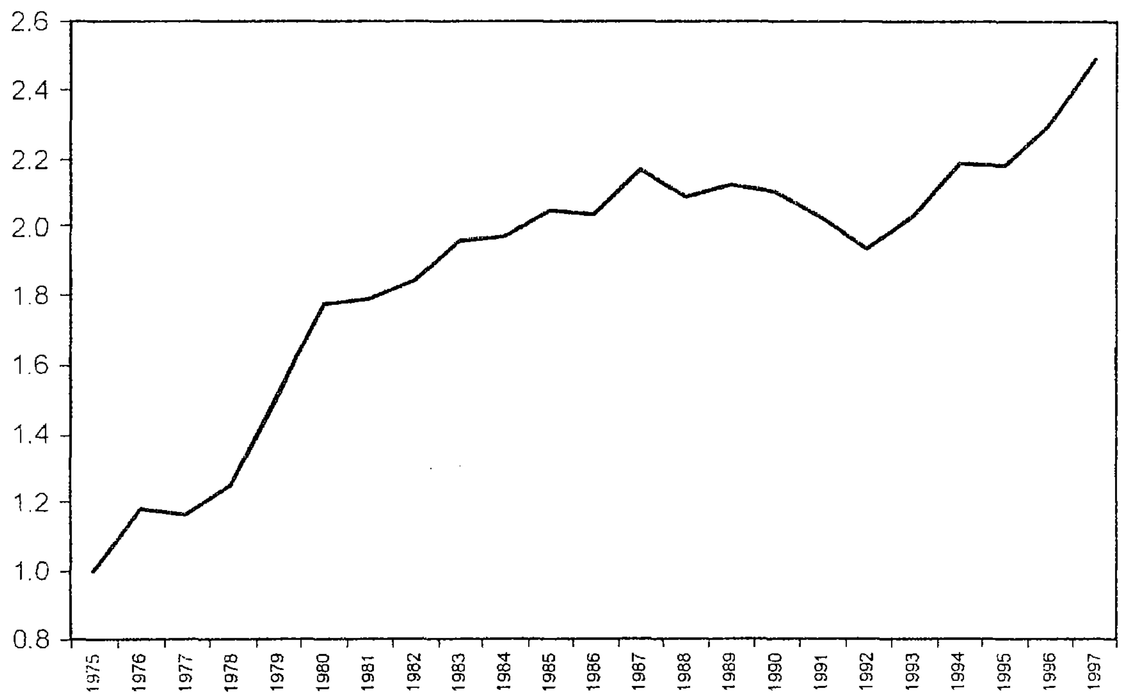
The second major conclusion from this research regards the nature of the property price history revealed in the exhibits. The price history is dominated by a general growth trend, with strong growth periods notable in the late 1970s and again in the mid-1990s. The price slump of the early 1990s is also apparent, though not terribly deep. The cumulative price level loss is only about 9% during the 1990-1992 period, after which there is a strong recovery in 1993-1994 and 1996-1997.

Comparison with NCREIF

In order to gain some insight into the difference between transaction-based and appraisal-based price indexes, as well as the possible difference between the performance of a broader population of commercial properties as compared to "institutional quality" properties, we have conducted a comparison of our RSR index and the corresponding NCREIF index. In order to make the comparison in a most direct manner, the NCREIF index we use is the NCREIF

Exhibit 4B

RSR Index Florida Commercial Property Price Level



Florida Index (NFI), which consists of all, and only, NCREIF properties in the state of Florida. Because NCREIF does not publish an index unless there are at least twenty properties in the index, the NFI only begins in late 1981, when there were twenty-three properties in the index (with an average value of $3.8 million per property at that time). By 1997 there were over 200 properties in the NFI (with an average individual property value over $23 million). Also, because the RSR is estimated on a calendar year basis and the NCREIF end of 1997 data are not yet available, our comparison extends only through 1996. Thus, we compare fifteen years of annual capital returns: 1982-1996.[27] The present analysis will not attempt to "unsmooth" the NFI, because our purpose is to compare our transaction-based index directly with the appraisal-based index to see how different the two appear. It is important, however, to make a different type of adjustment to the officially published NCREIF index for purposes of our comparison.

In breaking out the total return between the capital and income component, NCREIF subtracts all capital improvement expenditures from the numerator (value change component) of the capital-return formula (and not from the numerator of the income-return formula). In this way, the NCREIF index income component represents an accrual-based accounting income return (akin to an "earnings/price" ratio in the stock market), and the NCREIF capital return reflects purely the effect of the property market on property values, without considering the effect of capital improvements made by the property owners. Because of this definition, when one constructs an accumulated index level from the NCREIF capital return index, the result is not the same thing as a chart of property price movements. To convert the NCREIF capital return into an index of property price change based on appraised value, one would have to add back the capital expenditures each quarter. This is what we have done in our comparison. This adjustment should make our version of the NFI more directly comparable to our RSR index, as both

Exhibit 5A

Comparison of RSR versus NCREIF All Florida Commercial Property

Annual Return Summary Statistics (%)

	NFI	RSR
GMEAN	2.21	1.70
MEAN	2.28	1.78
STDEV	3.86	4.07
CORREL	50.59	

Return History

Year	NFI Price Level	Adj. NFI Return	RSR Price Level	RSR Return
1981	1.0000		1.0000	
1982	1.0263	2.63%	1.0307	3.07%
1983	1.1026	7.43%	1.0973	6.46%
1984	1.1875	7.70%	1.1033	0.55%
1985	1.2339	3.91%	1.1479	4.04%
1986	1.2722	3.10%	1.1397	-0.71%
1987	1.3354	4.97%	1.2155	6.65%
1988	1.4155	5.99%	1.1703	-3.72%
1989	1.4524	2.61%	1.1899	1.68%
1990	1.4573	0.34%	1.1771	-1.07%
1991	1.3931	-4.40%	1.1343	-3.63%
1992	1.3040	-6.39%	1.0819	-4.62%
1993	1.3278	1.83%	1.1379	5.17%
1994	1.3639	2.71%	1.2242	7.58%
1995	1.3684	0.33%	1.2216	-0.21%
1996	1.3887	1.48%	1.2884	5.47%

indexes will reflect property price changes, including the effect of capital improvements in the properties.[28]

The comparison between our RSR and the NFI is presented in Exhibit 5. The two indexes appear broadly similar, and are contemporaneously correlated at over +50% in the annual price changes. Both price indexes display a generally very gradual growth over the fifteen-year period, with the NFI exhibiting slightly greater growth overall (2.2% versus 1.7% per year).[29] The NFI also displays a slightly deeper drop in prices during the 1990-1992 property market recession. However, the difference in the degree to which institutional versus non-institutional property prices fell during the recession appears to be minimal in Florida (the RSR fell a total of 9.1% against the NFI fall of 10.5%.) In any case, both indexes agree in suggesting that the fall in commercial property prices in the early 1990s was less severe in Florida than it was in some other regions of the country.

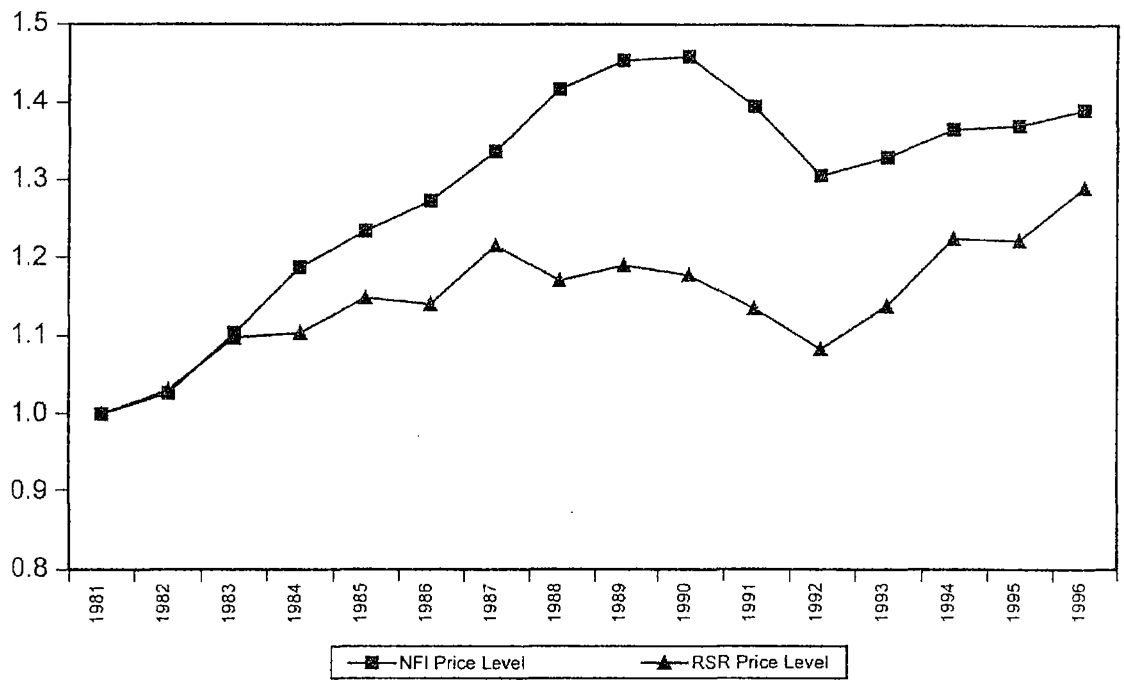
Also there do not appear to be major differences between the two indexes regarding "smoothing," or the statistical effects of appraisal as opposed to transaction-based valuation. Both indexes display nearly identical annual volatility (4.1% for the RSR versus 3.9% for the NFI), which is quite low.[30] However, on closer inspection, there are some differences between the RSR and NFI that do reveal some of the expected differences between a transactions-based versus appraisals-based index. The RSR appears slightly more "rough" overall in Exhibit 5B, and the RSR exhibits some volatility in the late 1980s that the NFI does not show (e.g., a sharp rise in 1987 and fall in 1988). There is also some evidence that the RSR is slightly "leading" in time, and the NFI slightly "lagging." For example, the RSR registers the beginning of the major drop of the early 1990s a little earlier than the NFI (the RSR begins falling in 1990, the NFI not until 1991), and the RSR return is correlated +47% with the NFI return one year later.[31] The annual NFI returns display strong inertia with positive first-order autocorrelation of 61%, while the RSR returns do not show positive autocorrelation over the 1982-1996 period.

Comparison with Housing

In a separate report, Gatzlaff [1997] has developed an RSR based index of Florida single-family home prices that is quite comparable to the RSR commercial price index we have developed in the present study.[32] This enables, what is to the authors' knowledge, the first head-to-head comparison of housing and commercial property market prices in the same geographical region. The two price indexes are summarized and compared over the 1976-1997 period in Exhibit 6. Again, we see a striking similarity at the broad level. The overall twenty-two-year growth rate is almost identical (4.3% for houses versus 4.2% per year for commercial property), and the contemporaneous correlation is +63%. The housing index appears modestly less volatile, with 5.1% annu-

Exhibit 5B

RSR versus NFI Price Level



al volatility compared to 7.0% in commercial property. Part of the housing index's lower volatility may reflect less noise due to a much larger property sample and use of the non-time-weighted RSR specification. It also seems likely, however, that housing prices really have been less volatile than commercial property in Florida during the historical period covered. Most notable is the fact that the property price slump of the early 1990s was much less pronounced in the housing sector. Indeed, Florida house prices appear to have experienced only a pause in their steady growth during the period when commercial prices were clearly falling.

Summary: It Works Pretty Well

This article reports the results of the development of the first repeat-sales transaction-based index of commercial property in the U.S., based on Florida's Department of Revenue data on all properties that sold twice during the last two decades. Based on this index-development work, we are encouraged that transaction-based commercial property index construction may be more feasible than previously thought. From a practical statistical perspective, the repeat-sales methodology appears to work well in filtering out transaction noise and producing return indexes that should be highly usable by decision-makers and academic analysts alike. Comparison of the RSR transaction-based index with the NCREIF Florida Index (appropriately adjusted) reveals interesting insights about the difference between appraisal and transaction returns and about the difference between "institutional quality" real estate performance as compared to a broader sample of commercial property. The somewhat surprising finding is that there appears to be relatively little difference between the appraisal-based and transaction-based indexes in terms of overall performance and annual volatility. The RSR index does register, however, price movements that the NCREIF index does not exhibit, and the RSR index may slightly lead the NCREIF index in time. Overall, the institutional quality properties represented by the NPI performed similarly to the

Exhibit 6A

Comparison of RSR Housing versus Commercial Property Price Index

Annual Return Summary Statistics (%)

	Houses		Comm.
GMEAN	4.28		4.23
MEAN	4.20		4.44
STDEV	5.07		6.99
CORREL		62.73	

Return History

Year	House Level	House Return	Comm. Level	Comm. Return
1975	1.00		1.00	
1976	1.02	2.10%	1.18	18.11%
1977	1.02	-0.07%	1.16	-1.46%
1978	1.20	17.38%	1.25	7.46%
1979	1.39	16.07%	1.50	19.90%
1980	1.60	15.00%	1.77	18.34%
1981	1.73	8.42%	1.79	0.73%
1982	1.77	1.96%	1.84	3.07%
1983	1.82	2.79%	1.96	6.46%
1984	1.86	2.59%	1.97	0.55%
1985	1.91	2.49%	2.05	4.04%
1986	1.95	1.85%	2.04	-0.71%
1987	2.01	3.17%	2.17	6.65%
1988	2.06	2.55%	2.09	-3.72%
1989	2.11	2.66%	2.13	1.68%
1990	2.16	2.20%	2.10	-1.07%
1991	2.17	0.33%	2.03	-3.63%
1992	2.17	0.37%	1.93	-4.62%
1993	2.22	2.26%	2.03	5.17%
1994	2.32	4.40%	2.19	7.58%
1995	2.37	2.13%	2.18	-0.21%
1996	2.46	3.83%	2.30	5.47%
1997	2.52	2.24%	2.49	7.98%

broader population of Florida commercial properties regarding their price level history. Both indexes experienced only about a 10% drop in price level during the early 1990s.

Endnotes

1 The authors thank the Real Estate Research Institute at the University of Indiana and the College of Business at Florida State University for the financial assistance they provided for this study.

2 There has been a long-running (and good natured) debate between one of the humble co-authors of this article, and the esteemed and learned chief editor of this journal, concerning the existence of "smoothing" in appraisal-based indexes. On the side of the existence of smoothing is a vast and impressive literature of great academic rigor and quality, including: Ross-Zisler [1991], Geltner [1989], Goetzmann [1990], Giacotto-Clapp [1992], Fisher-Geltner-Webb [1994], and Hendershott-Kane [1995], to name only a few of the most humble. On the other hand, weighing in on the side of "no-smoothing" are a paltry few seriously flawed articles and unpublished working papers, such as Webb-Miles-Guilkey [1992], Edelstein-Quan [1995], and Lai-Wang [1996]. Now, the low transactions-based price volatility we find has the chief editor crowing, but as the discerning reader will see in a subsequent footnote, Geltner has not admitted defeat! In any case, all parties to the debate agree that smoothing, if you define it only as reduced apparent volatility in real estate, makes relatively little difference to the real estate share in the optimal portfolio as long as real estate has low correlation with stocks and bonds.

3 See, for example, Colwell-Munneke-Trafzger [1998]. It has also been pointed out that the other major source of commercial real estate investment performance data, publicly-traded REITs, may tend to hold different types of properties than NCREIF members, and manage them differently in terms of cash flow and capital improvements. Such differences may be less pronounced in recent years.

4 This article is a condensation of a report for the Real Estate Research Institute (RERI), which partially funded this research. The full working paper is available from RERI at www.reri.org.

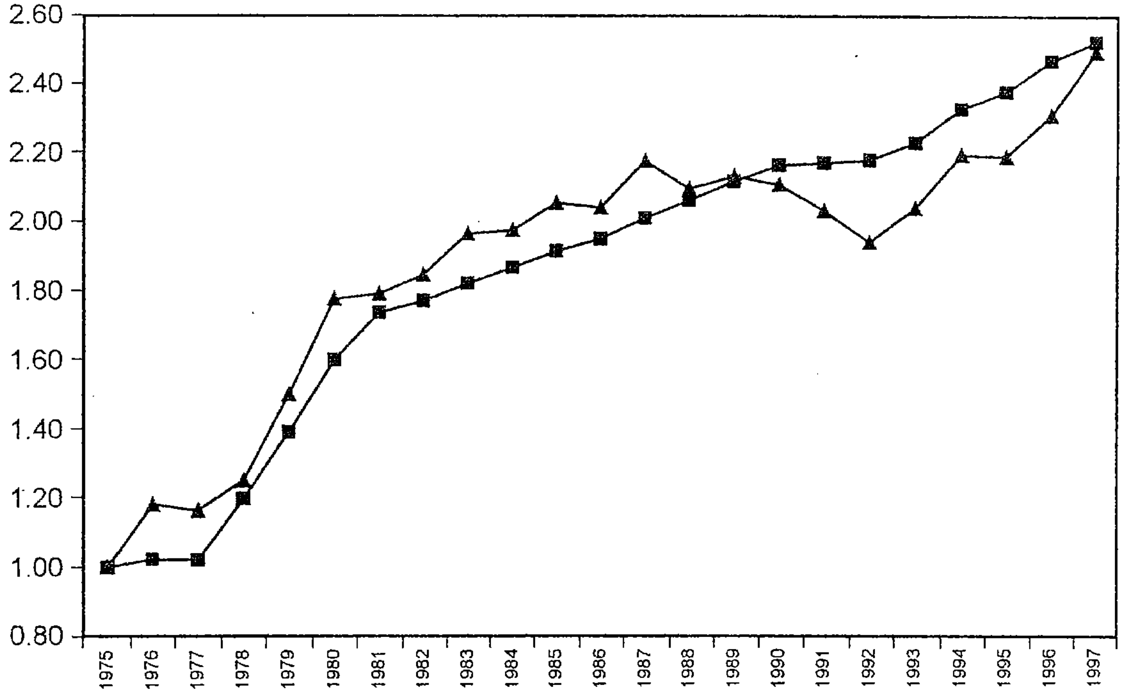
5 Temporal aggregation occurs when asset value indications from specific points in time are aggregated across time, thereby reflecting an *average value across time*. For example, if different individual properties within a population are valued at various times throughout 1998, and the same properties are valued again each one a year later, and then we computed a capital return to the population by comparing the average 1999 value with the average 1998 value, that return would reflect "temporal aggregation."

6 For example, FNMA and FHLMC regularly publish an RSR index of U.S. housing prices, and Florida State University regularly produces RSR house price indexes for the twenty Metropolitan Statistical Areas (MSAs) of Florida (published in "The State of Florida's Housing," University of Florida).

7 Transaction-based price indexes of commercial property were developed by various academic researchers at

Exhibit 6B

RSR Housing versus Commercial Price Level Indexes



least as early as the 1970s. A major attempt was by Gau [1985], using Vancouver apartments. Miles et al [1989] reviewed some of the early attempts, and concluded that a transactions-based index would not be practical for commercial property. A major issue was always how to control for quality differences between properties transacting in different time periods. It was recognized that, in principle, an hedonic model of property value could help with this problem. Early attempts to use hedonic models in this way, including Miles et al [1989], re-estimated purely cross-sectional hedonic models each period (or every few periods) using only the transactions occuring within those periods. With commercial property there are generally not enough transactions data for this approach to work very well. More recently, academic real estate researchers have begun to apply the classical Court-Griliches methodology. This approach uses a pooled time-series, cross-sectional database of transactions and derives the price index from the coefficients on time dummy variables. Such explicit time-dummy hedonic indexes of commercial properties have recently been developed by Fisher-Geltner-Webb [1994] which used properties sold from the NCREIF database; Colwell-Munneke-Trefzger [1998] which used a sample of Chicago properties; Downs-Slade [1996] which used nearly the entire population of all commercial property transactions in Phoenix, Arizona; and Goy-Londerville [1996] which used a sample of Vancouver properties.

8 The "omitted variables" problem occurs when a variable that is important in determining property value (say, the prestige of the street address, or the percentage of the building encumbered under an unfavorable long-term lease) must be left out of the right-hand-side of the valuation regression because the data is unavailable.

9 The term "noise" in this context refers to spurious excess volatility in the estimated price index, caused by random statistical estimation error in the regression parameters. This will be discussed more fully shortly.

10 In addition to the direct method presented here (which closely parallels the original development by Bailey-Muth-Nourse), the RSR can be derived indirectly from the hedonic model of property value, assuming that hedonic variables values and parameters remain constant across time within each property.

11 This follows directly from the definition of the natural log: $EXP(LN(1 + r)) \equiv 1 + r$.

12 Obviously, the type of periodic returns we are estimating are based only on the asset price change, and so represent only the capital or appreciation component of the

total return. To be more precise, we should think of the returns we are measuring as price-change returns that may reflect typical levels of routine capital improvements in the properties. This issue will be discussed further in the data description section that follows.

[13] To eliminate temporal aggregation in the estimated returns index, one can define the dummy variable to equal the *fraction* of the time period that falls between the two sales in chronological time. Thus, for example, suppose that for a certain observation the first sale occurred at the end of September 1995 and the second sale occurred at the end of September 1997. Then for an annual return index the dummy variable values for that observation would be 0.25 for 1995, 1.0 for 1996, and 0.75 for 1997. This time-weighted specification was first proposed by Bryan and Colwell [1982], and we employ it in the present analysis.

[14] Equation #2 is directly solved for $\hat{\beta}_{95}$, equation #4 is directly solved for $\hat{\beta}_{96}$, and then one can substitute into either equation #1 or #3 to observe: 0.1460 = 0.0488 + 0.0295+0.0677; and: 0.0783 = 0.0488 + 0.0295.

[15] Heteroskedasticity results when the likely magnitude of error differs for different observations. In this case, heteroskedasticity arises from the fact that there are two sources of transaction noise. First, each property may have an "idiosyncratic return component," that reflects the *true* difference between that specific property's capital return and the capital return of the population average during the interval between the two transactions. This component of noise would be a function of the amount of time that elapsed between the first and second transactions, because cumulative idiosyncratic returns accumulate over time. The second source of noise is a non-temporal component that could reflect "pricing error" which occurs at the time of each transaction, for example due to one party to the sale negotiating under financial duress.

[16] In WLS estimation, the observations that are likely to have larger errors (e.g., those with more time between the first and second sales) are given less weight in the regression estimation procedure. Another technical consideration is that the RSR specification described above and used in the present study estimates a geometric average index, equally weighted across properties. That is, the RSR estimated return each period is the *geometric* as opposed to *arithmetic* average across the individual property returns. This causes a minor downward bias in the estimated return, which we correct using an approximation suggested by Goetzmann [1991]. In applying this correction, we assume a cross-sectional standard deviation in transaction noise of 5% of the property price. (This is typical of the magnitude of non-temporal transaction noise found in studies of housing returns.)

[17] Note that our transaction dates are closing dates, not the date of price agreement between the parties. This may result in our index being slightly lagged behind the market.

[18] The Florida DOR categorizes properties using 100 land-use codes. The land uses selected for each sector were: apartment (multi-family, 03), retail (stores, 11; regional shopping centers, 15; and community shopping centers, 16), office (one-story offices, 17; multistory offices, 18; professional service buildings, 19; and insurance company offices, 24), hotel (hotels and motels, 39), and industrial (light manufacturing and printing, 41; warehousing and storage, 48). Of the data initially identified, 26,541 properties having the required data characteristics were recorded as selling at least once during the index construction period (apartment, 4,468; retail, 6,617; office, 6,924; hotel, 1,963; and industrial, 6,569).

[19] In addition, a series of steps were conducted to delete invalid observations (e.g., property title transfers) and apparent data errors. We have, however, no way to know if a sale was conducted with below-market interest rate debt financing from the seller, so we are unable to adjust for that. Keep in mind, however, that the fundamental observations we are working with are repeat-sales pairs. Below-market financing from the seller (hence an apparent property transaction price higher than the true market value) will bias the capital return (price change) estimate downward, or upward, depending on whether it was the first or second sale that had the favorable financing. Therefore, on average this effect may tend to largely cancel out across observations.

[20] In many most counties, the effective-year-built variable is updated when substantial capital improvements occur.

[21] In the RSR literature on housing price indexes, it has been noted that properties that are sold very quickly tend to come from a different population than those that are held longer. These differences may be due to nontemporal capital improvements at the time of purchase or other transaction-related characteristics.

[22] As we describe later in this article, we also adjust the NCREIF capital return to be comparable in this regard.

[23] Note that Exhibit 3 covers only sales during the last two years, during which there did not happen to be any repeat sales of very large properties, such as regional malls. During the entire history of our repeat-sales database, the largest single transaction observation included is $67 million.

[24] In addition, the database is dominated (72%) by the paired-sale observations of properties located in the four major metropolitan areas of Florida (i.e., Jacksonville, Miami, Orlando, and Tampa-St.Petersburg).

[25] The 1997 return is an annual figure estimated using the time-weighted RSR specification, but based only on data through July.

[26] Positive first-order autocorrelation in annual returns implies "inertia" in the returns: the return in one year tends to be followed by a similar return the next year. This suggests a partial response of market prices to the arrival of information, or lack of perfect "informational efficiency." Such a pattern is consistent with popular

perceptions of how real estate markets function, and consistent with evidence from transaction-based housing price indexes.

[27] This period of comparison also has the advantage of being subsequent to the period when the RSR exhibits some evidence of possible noise.

[28] In the NCREIF Index capital improvements are generally for routine items, such as tenant improvements when a new lease is signed. Major property development or rehabilitation is rare in the NCREIF Index properties. However, we cannot rule out that some development may be present in our adjusted NFI, that would result in an overstatement of apparent property price growth. Similarly, however, in our RSR, while we have attempted to filter from our index estimation sample any properties that experienced major redevelopment, we may have missed some cases. Nevertheless, we feel confident that the RSR well-represents property price changes including only routine and small-scale capital improvements, similar to what is reflected in our adjusted NFI price index.

[29] Note that the greater price appreciation on the part of the NFI does not necessarily imply greater total return from an investment perspective. The greater price appreciation may reflect a generally higher rate of capital improvement expenditures in the NCREIF properties. Furthermore, if there are institutional and non-institutional clienteles that result in segmented asset markets, this would be reflected in the long-run in differences in the earnings/price ratio, or current yield, not in the price appreciation rate, as cointegration between the two market segments would prevent long-run permanent divergence in price growth rates.

[30] OK, so this is where the esteemed chief editor is gloating and claiming victory over Geltner in the debate about smoothing. Geltner, however, is far from admitting defeat, though he is calling a tactical (but well-ordered) retreat. In the first place, it should be noted that our comparison here is at the annual frequency, whereas the most serious smoothing problems in the NCREIF index clearly occur at the quarterly frequency. Furthermore, if you read on, you will see the picture here is not all bleak for the smoothing side of the debate. Indeed, we find that the transaction-based index has much less positive first-order autocorrelation than the appraisal-based index, and it has been in precisely this way (by reducing autocorrelation) that most of the unsmoothing techniques used by academicians and practitioners have worked. At a deeper, more conceptual level, it is important to note that much of the debate about smoothing has occurred in the context of comparing real estate returns with those of publicly traded stocks and bonds, to arrive at an "apples to apples" metric of risk. In this regard, an index based on transactions in the property market does not get us all the way there, because the property market is very different in its functioning from the stock and bond markets. In particular, when contrasted with the stock or bond market, the commercial property market (and the transaction prices that reflect that market) exhibits much less liquidity, and liquidity levels that vary greatly across time. The property market also displays much greater inertia than the stock market, which results in much greater predictability of returns. In comparing risk, or even just volatility, between property market transaction prices and stock market transaction prices, one is still comparing apples and oranges. (And we note that REIT volatility is much greater than the volatility we find in the present article.)

[31] In contrast, there is no positive correlation between the NFI returns and subsequent RSR returns. Nevertheless, from the formal statistical perspective of "Granger Causality," there is no significant leading or lagging relationship between the two indexes.

[32] The housing RSR was estimated at a quarterly frequency for the 1985 to 1997 period and annually for the 1975 to 1984 period, without the time-weighted specification described previously. As a result, it probably displays some temporal aggregation smoothing in the early years not present in the commercial index. The housing index also was not adjusted for the difference between arithmetic and geometric cross-sectional averaging of returns. However, it is unlikely that these differences would significantly affect the comparison, and the use of the non-time-weighted specification serves to further filter out transaction noise in the early years.

References

Bailey, M., R. Muth, and H. Nourse. "A Regression Method for Real Estate Price Index Construction." *Journal of the American Statistical Association*, 58 (1963), pp. 933-942.

Bryan, T., and P. Colwell. "Housing Price Indexes." In C.F. Sirmans, ed., *Research in Real Estate*, Greenwich, CT: JAI Press, 2 (1982).

Case, K., and R. Shiller. "The Efficiency of the Market for Single-Family Homes." *American Economic Review*, 79 (1989), pp. 125-137.

Clapp, J., and C. Giacotto. "Estimating Price Indices for Residential Property: A Comparison of Repeat Sales and Assessed Value Methods." *Journal of the American Statistical Association*, 87 (1992), pp. 300-306.

Colwell, P., H. Munneke, and J. Trafzger. "The Stability of Office Property Values in the Post-TRA Period." *Real Estate Economics*, (forthcoming), 1998.

Court, A. "Hedonic Price Indexes with Automotive Examples." *The Dynamics of Automotive Demand*, General Motors Corporation, New York, 1939.

Downs, D.H., and B.A. Slade. "Characteristics of a Full-

disclosure, Transaction-based Index of Commercial Real Estate." Working paper, College of Business, University of Georgia, 1996.

Edelstein, R., and D. Quan. "How Does Appraisal Smothing Bias Real Estate Returns Measurement?" Working paper #95-240, Haas School of Business, University of California — Berkeley, 1995.

Fisher, J., D. Geltner, and B. Webb. "Value Indices of Commercial Real Estate: A Comparison of Index Construction Methods." *Journal of Real Estate Finance and Economics*, 9 (1994), pp. 137-164.

Gatzlaff, D. "House Price Appreciation." Ch. 5, in: The State of Florida's Housing, Real Estate Research Center, University of Florida, 1997.

Gatzlaff, D., and D. Haurin. "Sample Selection Bias and Repeat-Sales Index Estimates." *Journal of Real Estate Finance and Economics*, 14 (1997), pp. 33-50.

Gau, G. "Public Investment and Abnormal Returns in Real Estate Investment." *AREUEA Journal*, 13 (1985), pp.15-31.

Geltner, D. "Estimating Real Estate Systematic Risk from Aggregate Level Appraisal Based Returns." *AREUEA Journal*, 17 (1989), pp. 463-481.

Geltner, D., J. Hanson, and D. Loeb. "Land Investment in the Institutional Portfolio: Evidence from an Historical Return Index." *Real Estate Finance*, (forthcoming), 1997.

Giacotto, C., and J.Clapp. "Appraisal Based Real Estate Returns Under Alternative Market Regimes." *AREUEA Journal*, 20 (1992).

Goetzmann, W. "The Performance of Real Estate as an Asset Class." *Journal of Applied Corporate Finance*, 3 (1990), pp. 65-76.

Goetzmann, W. "The Accuracy of Real Estate Indices: Repeat Sale Estimators." *Journal of Real Estate Finance and Economics*, 5 (1992), pp. 5-54.

Goy, R., and J. Londerville. "Evaluation of Alternative Price Indices for Commercial & Investment Real Estate." Working paper, University of Guelph, 1996.

Griliches, Z., and I. Adelman. "On an Index of Quality Change." *Journal of the American Statistical Association*, 56 (1961), pp. 535-548.

Hendershott, P., and E. Kane. "U.S. Office Market Values During the Past Decade: How Distorted Have Appraisals Been?" *Real Estate Economics*, 23 (1995), pp. 101-116.

Lai, T., and K. Wang. "Appraisal Smoothing: The Other Side of the Story." California State University — Fullerton Working paper presented at 1997 AREUEA Annual Meeting, 1996.

Miles, M., D. Hartzell, D. Guilkey, and D. Sears. "Is a True Transactions-Based Real Estate Index Possible?" *Salomon Brothers Research Report*, November 1989.

Webb, R.B., M. Miles, and D. Guilkey. "Transactions-Driven Commercial Real Estate Returns: The Panacea to Asset Allocation Models?" *AREUEA Journal*, 20 (1992).

Ross, S., and R. Zisler. "Risk and Return in Real Estate." *Journal of Real Estate Finance and Economics*, 4 (1991) pp. 175-190.